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Training of spatial abilities through computer games – results on the relation between game's task and psychological measures that are used

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Abstract

The present study analyses the differences in scores for spatial abilities obtained by students who were trained using three types of treatment (computer games) in order to see if certain computer game's task may increase a certain spatial ability. 286 students were split in 3 intervention groups and one control group and tested repeatedly using four tests that measure spatial abilities. The findings sustain the idea that transfer through training is facilitated by the resemblance between training assignments and those that are tested and that complex spatial abilities, like spatial visualization are more difficult to train.

Keywords: computer games, mental rotation, spatial orientation, spatial visualisation, training

1. Introduction

Computers are no longer an instrument that can be used only by professionals and computer literacy is a must beginning with early age. There are many discussions regarding what advantages and what negative effects are related with computer use and research have covered a large area of interest beginning with career choices and ending with computer addiction. Even though there still are a lot of controversies, some findings regarding computer use continue to be confirmed. For example there are clear differences in time boys and girls spend on computers, with boys spending almost double then girls (Haltz, & Apple, 2011; Bonanno, & Kommers, 2005). Girls tend to use computers more for social contact

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and school assignments and boys more for game playing and entertainment (Giles, & Price, 2008). Females perceive computers as male appropriateness and their own ability to use these devices as poor and unsatisfactory (Farmer, 2008, Abbiss, 2008). There are gender differences in type of the video game played with males preferring action video games and girls role playing (Hamlen, 2011; David, 2009).

There are authors more centered on computer games that presents benefits of this activity especially on spatial abilities (Subrahmanyam, Greenfield, Kraut, & Gross, 2001; Quaiser-Pohl, Geiser, & Lehmann, 2006, De Lisi, & Wolford, 2002). There are others who emphasize the negative impact of gaming and the topic is connected with aggression (Haltz, & Appel, 2011; Wei, 2007). A comprehensive and substantial review of the literature upon video game in presented in Barlett, Anderson and Swing (2009) where the outcomes of the game playing are structured in confirmed, suspected and speculative, both negative and positive. Positive effects are difficult to track because of the complexity of variables involved in computer games playing, but can not be denied all toghether.

2. Objectives

Confirmed results on male ascendancy over female regarding mental rotation in corroboration with encouraging results on training opportunities through computer games (Terlecki, Newcombe, Little, 2008) placed us in front of a new challenge: what kind of computer games are useful in training certain spatial abilities in order to offer an affordable method to exercise them. We presumed that the type of game will produce different effect on spatial abilities test scores. Consequently the game Shapes will determine increase in spatial visualization (measured by image generation and blocks) compared with the other games and Block out will increase scores in mental rotation more than other games.

3. Method

3.1. Participants

286 students were involved in the study (mean age = 14,10 years, 55,5% males, 45,5% females). They were placed in four groups comparable for the following criteria: gender, age, IQ (tested with Raven's Standard Progressive Matrices) and spatial abilities. The assignments for the groups were random for approximately half of the participants and the other half was assign in respect with the mentioned criteria. All participants declared that they possess a computer at home. Three of the groups were instructed to play computer games for at least six hours and the fourth group didn't received any instructions. Students from experimental groups received CDs with computer games, playing rules, and follow up sheet and also they maintained contact with experimenter on a regular basis (two times a week).

3.2. Materials

The computer games selected for playing require visuo-spatial processing. First group received only *Shapes*, the second group received *Block-out*, and the third group received *3D Blocks, Cram jam, Cyclanoid, and Kiki the nano bot.*

Shapes: the game contains 50 levels; on each level one must fill the black shape on the screen living no gapes using smaller shapes available along the bottom of the screen. There are only a certain number of shapes available that can be placed in the given frame and they can be rotated in order to be placed in the proper orientation. The game uses mental rotation and spatial visualization, is somewhat monotone, and resembles tangram rules.

Blockout: a classic game, requiring mental rotation of three-dimensional shapes in order to complete the distant surface of a cube. The shapes can be rotated along axes X, Y and Z, clockwise and counter-clockwise. As the level is completed, the speed increases and the player must be quicker in deciding which of the possible rotation is better to complete the background. The other four games demand anticipation of the consequences of the moves a player intend to do in order to select the proper one and to solve the task. The strategy of playing involves spatial visualization and mental rotation.

There were used four spatial ability tests, pre and post intervention: Mental rotation test, Spatial orientation test and Image generation test are all component of BTPAC (ASCR, 2003). Blocks test - Clinciu version (Clinciu, 2004) adapted after Block design subtest from Wechsler Intelligence Scale for Children-Revised requires spatial visualization, gestalt comprehension and manual action, combining nonverbal intelligence and spatial conceptualization. The test showed a satisfying internal consistency in the present research (Chronbachs $\alpha = .78$ to $.82$).

All participants were tested before intervention and three to five weeks after, period in which students from experimental groups played the assigned games. Three of the participants were excluded because they didn't comply with the allocated chore.

4. Results

Multifactorial ANOVA analysis was used with type of game as independent variable and the difference in raw scores from post and pre-intervention for mental rotation, spatial orientation, image generation and blocks as dependent variables. Variance analysis was significant for two of the tests: mental rotation - $F_{(3,\ 279)}=8{,}41$ $p<.001$ (fig.1a) and spatial orientation $F_{(3,\ 279)}=7{,}85$ $p<.001$ (fig.1b). Helmert contrast showed significant differences for those enrolled in the control group compared with the rest of participants who played video games as follows: mental rotation - $t_{(282)} = 3{,}79$, $p<.001$, spatial orientation - $t_{(282)} = 4{,}51$ p $p<.001$) and blocks - $t_{(282)} = 2{,}05$ $p=0{,}04$.

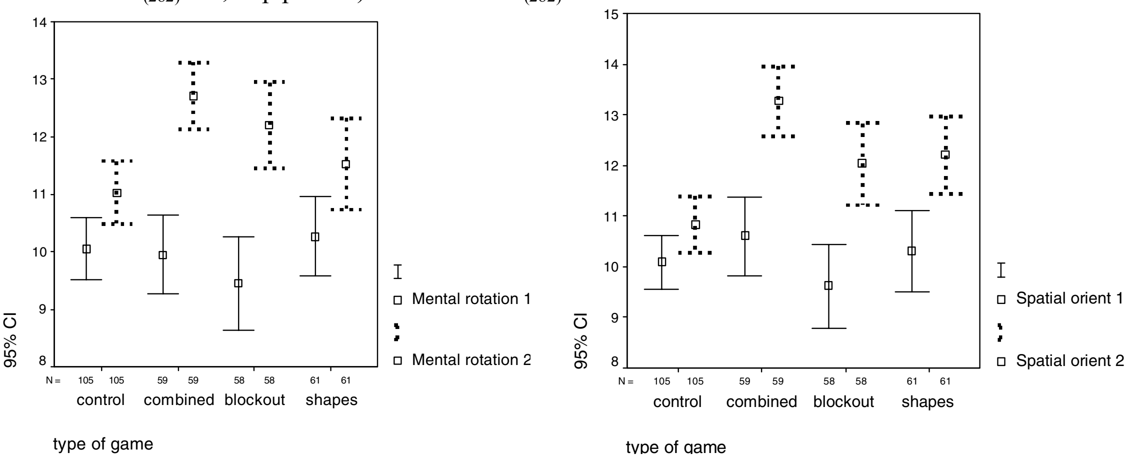

Fig. 1. (a) Increase in mental rotation scores after game playing; (b) Increase in spatial orientation scores after game playing

Results revealed better scores for mental rotation for those who played Block out compared with those who played Shapes: $t(118) = 2{,}92$ la $p= 0{,}04$ (fig.1a). A positive effect but under the threshold of statistical significance is obtained in image generation test by participants who played a combination of games and Shapes compared with students who played Block out or didn't played at all (fig. 2a) Similar, scores in blocks test are better for students who played four different games or Shapes (requires spatial visualization and gestalt comprehension) but doesn't reach the statistical significance (fig. 2b).

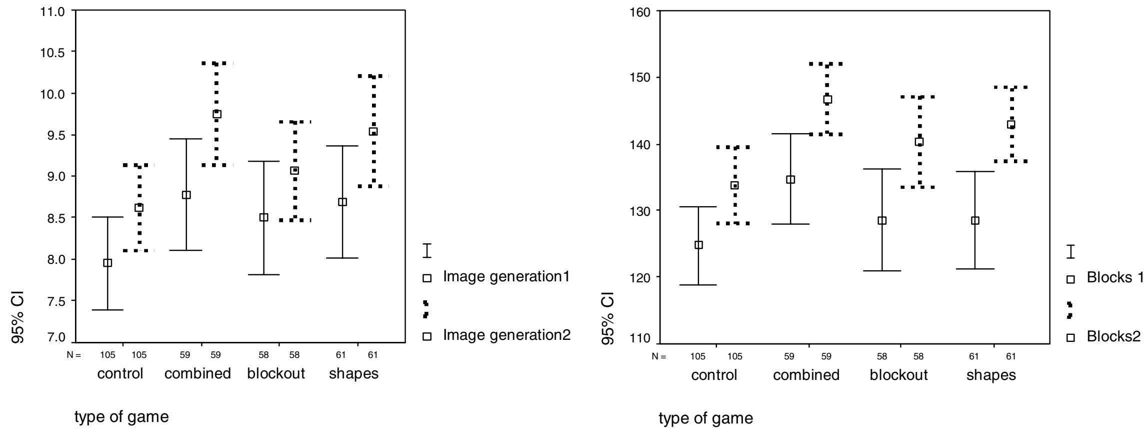

Fig. 2. (a) Increase in image generation scores after game playing; (b) Increase in blocks scores after game playing

Overall, the combined strategy (four different games) allowed improvements in tests results in all categories but the effect was under significance threshold.

5. Discussion

The present study aimed to relate the content of computer games with the benefits in scores for spatial abilities. The hypothesis was partial confirmed with Block out game contributing to improvement in mental rotation scores. Shapes, a dynamic, computer puzzle, has contributed to the increase in scores that measured spatial visualization but didn't reach the significance as expected. A general positive effect of computer games was obtained in enhancement of spatial orientation scores. Analyzing the statistics we have prove that computer games that are similar in tasks with psychological tests used afterward produce improvement in scores. The effect is produced after six hours of playing, results that confirm others findings (Quaiser-Pohl, Geiser, & Lehmann, 2006; De Lisi, & Wolford, 2002).

Another conclusion allowed by the present study is that spatial visualization, which is a complex cognitive ability that involves working memory and spatial attention is more difficult to train. There is a tendency in development of this ability after playing computer games but the tasks of the games didn't resembled the tasks from the tests. Spatial visualization requires multiple transformations upon visual stimuli, so, more studies are necessary to clarify the transferability of acquisition from games to tests and then to real-life activities.

There are some shortcomings of the present research: first, it was difficult to monitor the real time participants played the requested games and the research based on their claims. Second, the control group might also use computer games during the time of experiment that couldn't be out ruled (also true for experimental groups).

Nevertheless, the findings are in line with results from the literature (Barlett, Anderson, & Swing, 2009; Terlecki, Newcombe, Little, 2008) and sustain the idea that transfer through training is facilitated by the resemblance between training assignments and those that are tested and that complex spatial abilities, like spatial visualization are more difficult to train. Computer games can be used in training mental rotation and spatial orientation, two cognitive abilities that are important in scientific education and also in day by day living (way finding, map reading, driving, etc).

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